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ABSTRACT

This exploratory study of children's use of electronic text systems drew upon site visits, interviews, and data compilations for an overview and synthesis of issues. Systems studied included Green Thumb (videotext, Kentucky); Channel 2000 (videotext, Ohio); KCET (teletext, California); WETA (teletext, Washington, D.C.); QUBE (interactive cable, Ohio); Sesame Place (microcomputers, Pennsylvania); and Capital Children's Museum (microcomputers, Washington). Following the site visits and other data collection, two conceptualizations were undertaken. One, on behavioral issues in children's use of electronic text systems, is grounded in the literature on child development. The other, a features analysis of electronic text systems, specifies differences that may affect children's use of and learning from the systems. This five-chapter study report concludes with questions for future research organized according to the paradigm, "Who learns what from which electronic text system and with what effects on other learning and behavior?" A 30-item reference list is included. (Author/LMM)

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CHILDREN AND ELECTRONIC TEXT:
CHALLENGES AND OPPORTUNITIES
OF THE "NEW LITERACY"

An Exploratory Study

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ABSTRACT

Electronic text systems -- teletext, videotext, interactive cable, and microcomputers -- represent a second electronic revolution in the industrialized nations. Whereas the first electronic revolution of radio and television undermined the functional basis of literacy by providing entertainment and (albeit insufficient) information to nonliterates, the technologies of the second revolution depend more on literacy than even print media. At the same time, it is possible that intrinsically motivating aspects of electronic text use may cause children to read more, and at an earlier age.

This exploratory study of children's use of electronic text systems drew upon site visits, interviews, and compilations of data for an overview and synthesis of issues. Systems studied included Green Thumb (videotext, Kentucky); Channel 2000 (videotext, Ohio); KCET (teletext, California); WETA (teletext, Washington); QUBE (interactive cable, Ohio); Sesame Place (microcomputers, Pennsylvania); and Capital Children's Museum (microcomputers, Washington).

Following the site visits and other data collection, two conceptualizations were undertaken. One, on behavioral issues in children's use of electronic text systems, is grounded in the literature on child development. The other, a features analysis of electronic text systems, specifies differences that may affect children's use of, and learning from, the systems.

The report concludes with questions for future research, organized according to the paradigm, Who learns what from which electronic text system and with what effects on other learning and behavior?

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1. OBJECTIVES AND METHODS OF THE STUDY

Electronic Text and the "New Literacy"

In modern society, literacy[1] is the key to academic learning among children and "lifelong learning" among adults. The first electronic revolution of radio and television seemed to undermine the functional basis of literacy by providing preliterate children and nonliterate adults with knowledge that had been sealed from them in books. Although radio and television are widely used in developing nations to circumvent the slow process of training for literacy, their limitations as learning media have become apparent in industrialized nations like the United States. The nonliterate person who suffers no disadvantage as a member of the radio or television audience actually suffers increasing disadvantage as a worker, consumer, parent, and citizen. The information burden of these roles in American society has grown beyond the capacity of radio and television to inform.

Paradoxically, the second electronic revolution of teletext, videotext, interactive cable, and microcomputer systems[2] now spreading

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[1] The importance of literacy in modern society has caused it to be over-defined with functions extending far beyond "decoding" and "reading comprehension". The definitions of reading literacy and social intelligence overlap in the region of "critical evaluation" and "application" skills. In this report we use literacy in the narrower rather than the broader sense. Also, we do not draw an analogy between reading literacy and "computer literacy", which may have more in common with application skills like operating a calculator or driving a car. See Bormuth (1975) for a discussion of the narrower and broader definitions of reading literacy.

[2] Teletext refers to electronic text transmitted during the vertical blanking interval of a broadcast television signal, although teletext can also be transmitted in dedicated channels such as FM subcarriers. Teletext "frames" are broadcast in a frequently repeated sequence; the number of frames is limited by the length of time the sequence takes to repeat, since the user must wait for a given frame to reach the

throughout the United States and other industrialized nations depends more on literacy than even the print media of past decades. Computer displays of menus (lists of choices), instructions, and information can daunt the user who reads slowly or inaccurately. Unlike radio and television, the electronic text systems offer no misleading promise of learning without literacy. They will not be expected to close the "knowledge gap" between literate and nonliterate populations. From the outset, electronic text systems will favor the user who reads quickly and accurately. They will probably widen the "knowledge gap", and the advantages they provide to their users will certainly raise questions of equity.

It is also possible, however, that early exposure to electronic text systems, which are gamelike in many of their applications, may motivate children to read more, and at an earlier age. Children who are educationally disadvantaged for ethnic or economic reasons may particularly benefit from the qualities of individual pacing, responsiveness, and cultural neutrality that are characteristic of these systems.

Although electronic text systems will undoubtedly be common in schools by mid-decade, many of the installed systems on which we now base our speculations are found in homes[3]. Typical teletext, videotext, and interactive cable systems serve middle-class urban and suburban homes in cities like Columbus, Philadelphia, Dallas, Salt Lake City, etc. The most widely publicized systems, like QUBE in Columbus, find the majority of their subscribers in well-educated, information-rich homes where the additional benefits of electronic text systems are hard to distinguish from the many educational advantages that children in the homes already enjoy. Little is known about the demography of microcomputer homes, but it is a safe assumption that they also are skewed toward higher education and socioeconomic status.

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television set before it can be "captured" and displayed on the screen. Videotext refers to electronic text transmitted via cable, telephone, or other non-broadcast channels; typically videotext is also received on ordinary television sets equipped with decoders. Unlike teletext, which merely "captures" a signal that is being broadcast anyway, videotext requires a request channel from the user back to the distribution center; requested frames of videotext are sent out to the individual user. Because it is not necessary to broadcast videotext frames in a frequently repeated sequence, a videotext database can be orders of magnitude larger than a teletext database. Interactive cable encompasses more than electronic text. The return channel can also be used to request entertainment materials, vote in a referendum, purchase products, etc. Microcomputers are typically free-standing microprocessors that cost less than $2000 or $3000 and are operated with programs stored on tape, disk, or cartridge.

[3] Many more microcomputers are located in homes than in schools, and as yet there is virtually no school service from teletext, videotext, and interactive cable systems. KCET, the Los Angeles PBS station, is pioneering teletext service for schools.

There are exceptions to this pattern of diffusion. For example, the "Green Thumb Box" videotext system, consisting of a keypad and microprocessor connected to the family television set, operated in 200 Kentucky farm homes from early 1980 until mid-1981[4]. In order to test the benefits of videotext service for farm families at all socioeconomic levels, the federal-state Cooperative Extension Service distributed the free Green Thumb Boxes to families operating small farms as well as those operating large farms. Thus an opportunity was created to observe electronic text use by low-SES as well as high-SES families.

Our interest in children's use of electronic text is not restricted to any socioeconomic level, but it is worth noting that children in low-SES homes have had access to electronic text in several sites. These include Channel 2000 (Viewtel) in Columbus, Ohio; WETA Teletext and the Capital Children's Museum in Washington, D.C.; KCET Teletext in Los Angeles, California; and Sesame Place in Langhorne, Pennsylvania, among other sites.

An Exploratory Study

Large quantities of electronic text in a child's home or school environment are a new phenomenon. Two prerequisites of a rigorous assessment of the effects of electronic text are lacking at this time: (1) a demographically representative sample of children using electronic text; (2) a theoretical framework to focus the inquiry on particular effects. What is possible at this time is an exploratory study of the settings and occasions of children's use of electronic text. In the past months we have conducted such an exploratory study.

The range of sites where children could be observed using electronic text systems, although limited, was too large to be encompassed in this exploratory study. Accordingly, we first compiled a list of possible sites, rank ordered on several criteria such as: (1) diversity of children using the systems; (2) accessibility of sites for observation and interviews; (3) geographical contiguity of sites, as a factor in minimizing site visit costs. Chosen sites are described in Section 2 of this report, which also presents our impressions from the site visits.

In addition to the site visits, we interviewed several persons who designed, or are now managing, electronic text systems that children use. Further information on the visited sites as well as other sites was obtained from publications ranging from books and computer magazines to unpublished project reports.

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[4] Although the Green Thumb experimental phase is over, the service is still available to Kentucky farmers who can use their own terminals or home computers for access. Green Thumb-type systems have been established in other states. At the present time, "Grassroots" rural service based on Canada's TELIDON videotext technology is also diffusing rapidly. However, the cost of receiving equipment will undoubtedly lead to slower adoption by lower-SES farmers.

Informed by the site visits and other data-gathering activities, we began work on a conceptual framework to encompass effect variables as well as antecedent variables. Much of this framework, which appears in Section 3, derives from the theoretical literature on child development.

We also set to work on a parallel conceptual framework identifying the "features" of electronic text systems that distinguish them from each other. In research on interactive media (e.g., Martin, 1974; Paisley & Butler, 1977), such a framework is called a features analysis. It is one form of taxonomy. Without describing it as such, Bretz (1971) prepared a comprehensive features analysis of audio-visual and electronic media in common use at that time. Subsequent features analyses have been modeled to a considerable degree on Bretz's work. Our preliminary features analysis of electronic text systems is presented in Section 4.

Despite its small scope, this study suggests to us a number of questions for future research on the effects of electronic text systems on children's learning and development. These questions are discussed in Section 5.

2. CLOSE ENCOUNTERS IN THE THIRD GRADE

Eight-year-old Brian comes to visit his grandparents on their farm every few weeks. An avid reader, he enjoys sitting at their videotext terminal and calling up random "frames" of information, often for more than an hour. He begins by reading aloud the "menu" of frames of information, types in his choices, and dials up the videotext computer located in the County Extension Agent's office. His grandparents often sit with him as he uses the system. He enjoys reading aloud to them from the information displayed on the screen, although he does not understand everything he reads. His grandparents take pride in his reading ability and his enthusiasm for the videotext system.

In a large midwestern city, 12-year-old Susan uses the video encyclopedia on another videotext system to go beyond the scope of her school assignments. On several occasions, she has turned to the encyclopedia for information related to assignments in history and geography, summarized the frames of information, and submitted the homework to her somewhat amazed teacher.

In the same city, 13-year-old Maria is becoming interested in her future career. Using the videotext terminal at home, she reads weekly features on different careers. She would like to find out more about careers in teaching or science and eagerly calls up these frames when they are on-line. She also consults the career feature during other weeks and reads about jobs in transportation, health, and agriculture. The features include addresses to write for further information from government agencies. She has received stacks of career information in the mail.

Fifteen-year-old Stephen lives in a computer-rich environment. His family's interactive cable TV system also includes a personal computer that can be connected to an information utility providing the full text of several major newspapers, weather, sports, games, and movie reviews. Occasionally he calls up the President's schedule for the day. Stephen uses the full alphanumeric keyboard of the computer to type messages that he will send to various "electronic bulletin boards" and "CB" discussion groups[5]. Stephen uses the information utility so frequently

that his parents now negotiate his allowance in units of "connect hours".

Stephen's fondness for computers began early. When he was younger, he was a devoted collector of comic books. By the age of eleven, he found that his collection had outgrown his ability to catalog it. On Saturday mornings, he began going with his father to the office, where he could use an IBM computer to catalog his comic books. He began teaching himself BASIC and has now acquired an impressive command of the computer language. A friend has a TRS-80 microcomputer, and together they are writing a program to play Dungeons and Dragons, the fantasy game that has a devoted following among adolescents.

Stephen's mother says that his work with computers has reduced the time he spends watching television. An increasing amount of his time is spent participating in the CB discussion groups, where members of different ages, occupations, and backgrounds log in across the country. Stephen's "CB handle" is Golum, the obsessed ghoul from Lord of the Rings.

In another city, fifth-, sixth-, and seventh-graders ride the subway to a major university several times a week. They are learning to use word processors. Researchers want to know whether computer-based systems can improve children's writing skills and encourage a positive attitude toward writing and composition. In the beginning, the students are taught typing and some basic commands. Their assignments include writing a brief description of themselves, a letter to a friend, and a story.

The observations of children working with the system are impressive. The children spend longer amounts of time at their assignments than their counterparts using paper and pencil. They engage in a process of peer review, not only sending drafts to each other over the system, but also comparing the appearance of the finished product on paper. They eagerly share newfound "tricks" for producing a prettier page. Not only do their technical skills improve, but they spend more time with their writing and are enthusiastic about it.

On the West Coast, Maria Esquivel, a third-grade teacher, is using the PBS station's teletext service in a lesson on the first moon walk. The lesson combines science, history, reading, and writing. The class reads the four frames of background information, colorfully presented on the screen, in unison. Ms. Esquivel reviews the pronunciation and meaning of new words. The screen then displays a short quiz on the moon walk, and children take turns with the hand-held keypad to reveal correct answers. Eight-year-old Julia, who was born five years after the event, says, "I didn't know who the first man on the moon was. Now I

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[5] "Real-time" electronic conversations have the misleading "CB" label because they are similarly spontaneous and rich in jargon. The distinction between electronic bulletin boards and real-time conversation is discussed on page 35.

know about Neil Armstrong."

Second-graders Emma and Pedro are learning a simple but powerful computer language developed for children. Emma has made objects move around the screen in a random pattern. She wants to change the background color of the display and types "COLORBACKGROUND: RED." The background instantly changes to red. Pedro suggests doing the same thing for yellow, blue, and purple, and they execute those commands.

Pedro wonders whether they can make the computer change the colors in sequence by itself. Pedro types in:

```
TO CHANGE
COLOR BACKGROUND: RED, YELLOW
END
```

To run the program, they type CHANGE. The computer answers, "RED, HAS NO VALUE AT LEVEL 1 LINE 1 OF CHANGE." Emma and Pedro wonder what the problem is; they guess that they need separate statements for each color. They revise the program to:

```
TO CHANGE
COLORBACKGROUND: RED
COLORBACKGROUND: YELLOW
END
```

Emma says she would like the program not to end after it turns the display yellow but to change from red to yellow and back again continuously. They add a CHANGE command before the END statement and run the program. It works. They then modify the program to add more colors and delay longer before each color change[6].

These examples are not drawn from a future scenario of children's use of electronic text systems. These are actual encounters between children and teletext, videotext, interactive cable, and microcomputers. In a few years they will be commonplace in classrooms and homes across the country. Based on observations, interviews, and other data sources, this report presents a synthesis of issues related to close encounters between children and electronic text systems.

Videotext Systems

Our observations of children and videotext began in two Kentucky farm counties: Shelby County, located in the bluegrass belt midway between Louisville and Lexington, and Todd County, located in the

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[6] This program generates graphics, not text. Note, however, the considerable amount of text that children read and type while using the program.

grain-producing region of southwestern Kentucky. These counties were selected by the Kentucky Cooperative Extension Service to participate in the USDA-sponsored trial of the "Green Thumb Box" agricultural videotext system. One hundred families in each county were chosen by local committees composed of farmers and extension personnel to receive the Green Thumb Boxes -- simple videotext keypads that connected to home telephones and television sets. The local committees made an effort to distribute the Green Thumb Boxes equitably to small farms as well as large farms[7].

In our survey of 194 Green Thumb farm families in the summer of 1981, we found that more than two-thirds had children living at home. Preschoolers accounted for 14% of the 257 children; 33% were 5 to 11 years old; 31% were 12 to 18 years old; 22% were 19 and older (the latter might be classified as adults, but they were reported as "children living at home" by their parents, the principal respondents in our survey).

Hundreds of frames of information, varying in number and content from month to month, were available via the Green Thumb Boxes. Of special interest to children were the frames of 4-H information, in particular a sequence on career exploration which included several game activities. However, we did not find a strong perception of children's information versus adult information. Children were quite likely to access weather maps, forecasts, and farming information.

Procedures for using Green Thumb are typical of most videotext systems. They will be described briefly to illustrate the skills that children acquire in order to use videotext. First, the user consults a printed list of information categories and their code numbers. Second, after checking that the Green Thumb Box and the television set are connected to each other and switched on, the user types in an identification number. Third, the user types in the numbers of the chosen Green Thumb frames. Fourth, a "delimiter code", the # sign, is pressed twice to indicate that the request is complete. At this point the television screen flashes "PLACE CALL" and the user turns to the telephone to dial the computer's number. When the carrier tone is heard in the telephone receiver, the user presses the "SEND" key to transmit the request to the computer. For the next minute or more the Green Thumb Box is occupied receiving frames as they are "downloaded" from the computer. When the television screen displays "READY TO VIEW", the user presses "NEXT PAGE" to begin reading the frames. "LAST PAGE" displays the frames in a reverse sequence. Ordinarily, 25 of more key presses, together with telephone dialing, are required to view a sequence of Green Thumb frames.

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[7] Demographic data obtained in the overall Green Thumb evaluation, which was conducted for USDA by the Stanford Institute for Communication Research, indicated that large farms were somewhat overrepresented among Green Thumb Box recipients. This may be explained by the FCC public safety regulation that users of telephone-based videotext systems must have access to private lines rather than party lines. Nonetheless, farms receiving Green Thumb Boxes ranged in size from less than a hundred acres to several thousand acres.

These procedures are moderately difficult for adults or children to follow at first. After a few trials, however, they seem as simple as playing a video game. The procedures can be categorized in three sequences[8]:

1. Set initial conditions (e.g., activity to be performed) via menu choices and commands -- set-up.

2. Confirm set-up and transfer control to the system so that substantive use can begin -- check and go.

3. Engage in substantive use via menu choices, commands, and response input -- proceed with use.

Even in the case of Green Thumb, which has no error-trapping routines, the separation of set-up and proceed with use by the check and go sequence is beneficial for a child because it is forgiving of typing errors (assuming that the child can detect errors during the check and go sequence).

Children and adults differ in their world knowledge, of course. One aspect of world knowledge is a reasonably accurate ranking of probabilities concerning "what goes wrong." Like other experimental videotext systems, Green Thumb was plagued by technical problems. Quite often, after check and go, the television screen flashed "ABORT", which might confuse any user because it has the grammatical form of an imperative verb but is to be read as a noun. An adult user would interpret "ABORT" as indicating a computer lapse or perhaps a bad telephone line but not, for example, a problem in the television set. A sophisticated adult user would re-initiate the request, listen momentarily to the quality of the carrier tone, and hope that the computer had sent out a burp rather than a dying gasp.

Although children's world knowledge grows with every encounter, "ABORT" is likely to mystify them at first. After check and go, children expect the television set to display the frames they requested. If they see something else instead, they may suspect that the television set is broken. Fortunately, because children live in a world in which things inexplicably go wrong anyway, they are accustomed to trying again. By re-initiating the request, they may reach a satisfactory solution. However, if the problem requires adaptation rather than repetition of steps, they may become frustrated by a message like "ABORT" which tells them something is wrong but doesn't tell them what to do about it.

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[8] The following terms are our own invention and do not correspond to the control features of any system. Hence they should not be misinterpreted as actual menu choices or commands.

While Green Thumb caused us to think about children's procedural success in using a videotext system with limited control features, our observations of Channel 2000 (now Viewtel) took us in a different direction. Unlike Green Thumb, Channel 2000's set-up begins with a telephone connection to the computer: no menu choices or commands are made prior to connection. Thus the user knows at the outset that a successful connection has been made with the computer. Other features of Channel 2000 interaction (described in Section 4) make the system more "user friendly" than Green Thumb. Our attention was drawn, therefore, from procedural to substantive aspects of use.

Channel 2000's videotext experiment in Columbus was undertaken as a joint venture between the Online Computer Library Center (OCLC), which developed and operated the system, and Bank One, which offered on-line financial services and provided incremental funding for the field test. Channel 2000 videotext was used by 200 Columbus-area households from October through December 1980.

The Channel 2000 equipment in each household consisted of a keypad[9] and a decoder box incorporating an acoustic coupler for the telephone. Channel 2000 was designed to use the telephone continuously while information was being retrieved or displayed. The advantage of a continuous connection is that selections do not have to be batched in a single request list, as in the case of Green Thumb. The Channel 2000 user could look at some frames and then select other frames in the same session. The disadvantage of a continuous connection is that the telephone line is not available for other uses.

Seven principal types of services were offered by Channel 2000. These can be grouped in four categories:

1. Academic or reference information. The Video Encyclopedia, otherwise know as the Academic American Encyclopedia, contained 32,000 articles ranging in length from 1 frame to more than 300 frames. The Video Catalog contained 300,000 records of the Columbus and Franklin County Public Library catalog.

2. Community information. A Public Information Service and a Community Calendar were searchable online.

3. Learning tools. Early Reader and Math That Counts, both developed by Ohio State University, were intended for preschool and elementary school children, respectively. Early Reader frames taught word relationships through rhymes. The problem sets of Math That Counts were grouped by grade level from kindergarten through sixth grade.

4. Home banking. Channel 2000 users who were also customers of Bank One could monitor their accounts and pay bills

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[9] The Channel 2000 keypad is described further on page 30.

through the system.

Much-used services of children in the 200 households included the Video Encyclopedia, the Video Catalog, Early Reader, and Math That Counts. However, they also used the community information services, in particular the Community Calendar. While we did not see the services used in this particular way, it would have been easy for an older child to:

-- note an event, say a celebration of the anniversary of the Louisiana Purchase, listed in the Community Calendar;

-- turn to the Video Encyclopedia for an explanation of what the Louisiana Purchase was about;

-- consult the Video Catalog to determine if books on the Louisiana Purchase could be obtained from the public library.

-- order the books for home delivery[10].

Teletext Systems

In contrast to videotext systems, which provide access via telephone or cable to extensive text files and other databases, teletext systems, which must transmit their entire contents serially during the vertical blanking interval of the broadcast television signal, offer a limited menu of selections, rarely exceeding 300 frames overall. However, there are compensating features, particularly for children's use. The teletext user does not need to establish a telephone or cable connection at the beginning of each use session; the teletext signal is already available at the television receiver, ready to be decoded and displayed on the screen. Furthermore, since teletext is a child of the mass media, it is acquiring much of the slickness and entertainment value of its parents. At their best, teletext frames are "newsy" and colorfully illustrated. Finally, it is our impression that the necessary brevity of teletext items makes them attractive to children.

KCET, the Los Angeles PBS station, has introduced the "NOW!" teletext service using Antiope technology from France[11]. KCET transmits from 60 to 80 pages of text each day, including news, sports, weather, book and movie reviews, entertainment guide, financial trends, and two children's

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[10] Of course, only a few users could be served by the public library's limited holdings on any subject. If the library wished to provide background information keyed to community events, it might need to prepare its own videotext frames.

[11] KNXT (CBS) and KNBC (NBC) are also participating in the Antiope-based Los Angeles Teletext Project.

features. During the trial period, decoders have been placed in 100 homes, 6 schools, and about 15 public sites throughout Los Angeles[12]. The 100 homes are participating in an ongoing study of teletext usage. Meters attached to the television sets record the time, channel, and teletext pages accessed.

KCET's feature for in-home viewing by children is called Popsicle. Broadcast during after-school hours, Popsicle provides information, quizzes, and children's activities.

The feature for in-school viewing, Think Shop, is keyed to two instructional programs broadcast by KCET. Formative research conducted in the six schools[13] participating in the Think Shop trial indicates that the series has positive effects on student's motivation and learning. Think Shop is used primarily in three ways:

1. Teaching current events -- students read news stories appearing in NOW! and answer questions posed by Think Shop.

2. Reinforcing instructional programs -- after viewing a KCET television program, students work on exercises broadcast over Think Shop.

3. Enriching the curriculum -- stand-alone units have been developed, often at teachers' request, to address topics such as handicapped awareness, space exploration, and computer literacy.

Think Shop quizzes take advantage of the system's "reveal button". When the button is pressed, answers appear on the screen next to questions.

Teachers and librarians using the Popsicle and Think Shop features believe that children are motivated to read the teletext screens. The emphasis placed on oral reading and on discussion of the teletext vocabulary may also help Hispanic students who are learning English as a second language.

WETA, the PBS station in Washington, is conducting a teletext trial with funding from the Corporation for Public Broadcasting, the National Science Foundation, the Department of Education, and the National Telecommunications and Information Administration. The trial utilizes the Canadian TELIDON system. The Alternate Media Center of New York University is providing implementation, software, and research support. Beginning in mid-1981, WETA teletext was made available to 40 selected

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[12] The decoders have 4,000 character memories, enough to capture 4 pages of teletext, with an average access time of 5 seconds.

[13] One of the six elementary schools is in a rural setting; another serves a Hispanic neighborhood.

households and 10 public sites, including the public library, the Capital Children's Museum, the Smithsonian Institution, and the Jewish Community Center.

About 120 pages are sent daily with the WETA broadcast signal, using four lines of the vertical blanking interval. Of the 120, about 80-90 are new each day; the rest are weekly features. The service is organized in nine categories: news, weather, money, sports, library, entertainment, consumer comparison shopping, a special feature, and consumer news. Providers of pages include The Washington Post, National Weather Service, a consumer advocacy group called Consumer Checkbook, the District of Columbia Public Library, and the Capital Children's Museum. The latter two contribute pages for the Saturday children's feature, which at the time of our site visit included information on collecting postcards, making puppets, dinosaurs, book reviews, and local events for children. The WETA staff essentially serve as editors for the service, monitoring the contributions of providers and offering suggestions and changes.

The WETA teletext pages offer attractive high-resolution graphics, the result of much design work by the teletext staff. The major drawback, and apparently the bane of all teletext systems, is access time. When the project first started broadcasting, access time for pages was as high as ninety seconds. This figure represents the time required for all 120 pages to cycle past the user's decoder. The "frame-grabbing" time has since been reduced to a maximum of 25 seconds.

A major obstacle has been the amount of memory in the decoder. Currently the WETA Telidon decoders have 3,000 characters of memory, enough for about 5 pages of text from The Washington Post but only one page of graphics.

The Alternate Media Center's research design includes in-home interviews with the 40 user households, diaries kept by each family on their usage, and a transaction tape of each keystroke and page accessed. The households were randomly selected from a market research sample of the Washington metropolitan area. The first survey was conducted before broadcasting began, and a second survey was conducted in the fall of 1981. Of the 35 households who provided age data on their families, 13 have children under the age of 18; 11 have children 12 and under.

A children's librarian at the District of Columbia Public Library offered perceptive comments based on her observations of library visitors who used the decoder in the entrance to the library. The keypad itself, resembling a calculator, is placed on a pedestal about four feet high, effectively barring use by younger children. The librarian says that 8th- to 10th-grade children are the most frequent users of the system and often are watched by adults standing behind them who are trying to learn how to use the decoder. After the teenagers leave, the adults walk up to the decoder and follow the procedure they observed.

The librarian made the startling comment that she has never seen a girl or woman use the system. Her observation accords with British data

from teletext trials: in this early phase of teletext operation, most users are males.

Observations of the use of the WETA teletext system indicate that the entertainment pages, which offer such content as horoscopes, movie listings, and movie reviews, are the most popular with adolescents. Sports and the weather maps are also frequently accessed.

WETA's public library site is located in a minority neighborhood in downtown Washington. The teletext system is used by minority students who come to the library to work on school assignments. The observant librarian, who is a member of a minority group herself, believes that the system is used by many teenagers who would be classified as poor readers in school. Although almost all of the information provided by the system is textual, the visually attractive pages and the game-like decoder have captured the interest of teenagers across a range of reading levels.

Interactive Cable

Since 1977, the Warner Cable Company has operated the first American interactive cable system in Columbus, Ohio. QUBE has approximately 30,000 users, for the most part middle- to upper-class families in Columbus and adjoining suburbs. A home console presents the viewer with 10 selections from each of three services, for a total of 30 channels. The premium service offers first-run movies, sports, a children's channel and other features on a pay-per-view basis. The regular service offers the network affiliates and independent stations. The community service includes local community programming and special programs that may be narrowcast to specific households among the QUBE subscribers. Five response buttons on the console are used for viewer response in interactive mode.

Currently the interactive capability of QUBE is used three or four times daily, typically posing questions to the audiences for local talk/variety shows (Columbus Alive, Take 2) on community issues. Of the several families interviewed during this trip, there was limited enthusiasm for the interactive use of QUBE. Most families said they responded on their consoles during the early months of QUBE operations because of its novelty, but that later they rarely viewed interactive programs.

A recent innovation on QUBE is to make CompuServe, a national videotext system based in Columbus, available to 10 selected households. For the first time, information databases usually accessed via telephone lines are now available to cable subscribers. Although only a "dumb" terminal is needed to access CompuServe, Warner has provided the test households with Atari 800 microcomputers. If they wish, the families can disconnect the Ataris from the cable system and use them as free-standing computers. During this trial the microcomputers are free, but CompuServe use is charged at $5 per hour.

CompuServe is the H.R. Block-owned company that began as a project to make use of the Block computers during evening downtime. Thus, CompuServe is available to users only after 6 PM weekdays and on weekends. The entire CompuServe service is available to the selected QUBE households: full text of 8 major newspapers (including The New York Times and The Washington Post), sports, weather, home management, an encyclopedia, electronic mail, national bulletin board, and stock market quotations. The potential also exists to have CompuServe's MicroNET software downloaded into users' microcomputers for home/business computing.

The ten households selected to participate in QUBE's CompuServe trial were recruited from the viewers of a QUBE broadcast describing the new service. An effort was made to select families that were not experienced in the use of microcomputers or videotext service. Questionnaires and interviews are being used to monitor use of, and attitudes toward, QUBE/CompuServe.

Although the QUBE/CompuServe experiment began just before our site visit to Columbus, some anecdotal findings were reported by the QUBE research staff. Games, newspapers, and electronic mail seem to be the most popular CompuServe features. Using electronic mail, children in different parts of the city communicate with each other about games.

Microcomputers

In the future, children will probably read more electronic text on the screens of microcomputers than on the screens of videotext, teletext, or interactive cable systems. As this report is being prepared, two major computer companies have announced full-feature microcomputers at $100 and $150; both will be sold in thousands of retail outlets. It is predictable that families at all socioeconomic levels will buy these or other microcomputers for their many entertainment, education, and home management uses. School adoptions will increase proportionately.

However, it does not follow that all children will benefit equally from the microcomputers in their homes and classrooms. In the foreseeable future, parents and teachers will be hard-pressed to identify and obtain good software for the microcomputers. In some homes and classrooms, children will be interacting with programs of amazing power and subtlety. In other homes, they will only be playing "spacewar" games. In other classrooms, they will only be drilling.

We observed children using microcomputers in several sites[14]. Two of these sites gave us visions of a future in which learning from microcomputers is one of the most exciting activities that children engage in every day, at school and home.

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[14] Not including the LOGO Project at MIT, to which our travel funds could not take us. Fortunately, the activities of the LOGO Project are well described in the book Mindstorms (Papert, 1980).

Sesame Place in Langhorne, Pennsylvania is a joint venture between the Children's Television Workshop and Busch Entertainment Corporation, operators of Busch Gardens and other theme parks. For more than three years, CTW has been designing and testing the unique hardware and software that fills the Computer Gallery at Sesame Place. Fifty-six Apple microcomputers are literally "at the heart" of 70 educational games that children can play in the Gallery. Children do not use the Apple's own keyboard[15], which is hidden in a colorful console that also contains the video display. CTW designed its own oversize, alphabetically organized keyboard on which additional keys allow children to control screen graphics.

Several of the games feature the Sesame Street Muppets. For example, in a recognition game the child guesses the Muppet's identity as the screen slowly resolves the features of a Muppet face. Some of the other games are specially designed (e.g., Flash Firefly, in which the child moves Flash around the city, restoring lights during an energy crisis). Others are adaptations of popular microcomputer games (e.g., Hangman), in which violent action and images have been replaced with benign reinforcements for correct responses.

The Sesame Place microcomputers operate on a pay-as-you-play basis. Tokens (three for a dollar) activate the microcomputers for about four minutes per token. Thus the relative popularity of the 70 games offered in the Computer Gallery is determined by what children and their parents are willing to pay for. Twenty of the games are now being prepared for sale on the educational software market.

At the Capital Children's Museum in Washington, microcomputers donated by the Atari Corporation can be used without charge in the Future Center. The twin emphases of the Future Center are computer familiarity and entertainment. Classes lasting from one to six sessions have been designed for children as young as three as well as for adults. The Future Center staff and its visitors overlap in age; much of the programming is done by teenagers on the staff.

The Future Center offers an instructive comparison with the Computer Gallery at Sesame Place. The Future Center (at least at the time of our visit) has an unfinished, and perhaps unfinishable, character. Young staff members, working on new programs for visitors, sit at the same computers that visitors use during classes and drop-in hours. Visitors also work on programs; screens are full of program statements rather than the flashy colors and animation of running programs. The Future Center is a workshop, not a play center. Many visitors would be less intrigued, and perhaps see fewer examples of what microcomputers can do, than in the Computer Gallery at Sesame Place. However, other visitors join in the "do it yourself" spirit and learn more about microcomputers than they could in the Computer Gallery.

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[15] Microcomputer keyboards are a problem for both children and adults because of several keys that can inadvertently stop a program. This point is discussed on page 29 of Section 4.

3. BEHAVIORAL ISSUES IN CHILDREN'S USE OF ELECTRONIC TEXT SYSTEMS

Children's use of, and learning from, electronic text systems present important theoretical issues related to their cognitive and social development. In this section, a series of these issues will be addressed, drawing upon relevant literature from developmental psychology, education, and ongoing research on children's learning from computers.

This discussion proceeds without explicit regard for specific types of electronic text systems. It is important to bear in mind that both hardware and software differences among the systems (see Section 4) will determine to a large extent the types of learning that will occur. For instance, whether the child is commanding the computer or simply responding to menu choices is an important distinction.

ISSUES IN COGNITIVE DEVELOPMENT

Electronic text systems hold the promise of helping children become better thinkers. Within the past decade and especially during the past three years, a small but growing group of psychologists and other researchers has devoted attention to the effects of electronic text systems (typically, microcomputers) on the cognitive development of children. Many electronic text systems have, for children, the dual identity of both games and intelligent machines. Their game-like qualities hold the interest and motivation of children, much like the entertainment quality of television. At the same time, the special intelligence of computers helps children assimilate and analyze information, discover the processes of thinking, and acquire strategies for problem-solving.

The Piagetian Perspective

When researchers discuss the potential of computers to help children become better thinkers, the most frequently invoked concepts come from

the work of Jean Piaget, the Swiss psychologist and epistemologist. One of the best-known researchers in the field of computers and children is Seymour Papert of MIT, who worked with Piaget. In his book, Mindstorms (1980), Papert discusses the impact of computers upon children's progress through Piaget's concrete- and formal-operational stages of cognitive development.

Concrete operations, typically seen in children between the ages of seven and eleven, are characterized by the development of the child's ability to create and manipulate mental representations of the physical world. For instance, one aspect of the concrete-operational child's thinking is conservation of mass, length, and weight: the child is able to perceive the constancy of an object despite outward changes in shape. The child is also able to classify (organize objects into hierarchies of classes) and seriate (organize objects in order along one dimension, such as height). He or she is able to take the perspective of others, in a visual sense. In general, the concrete-operational child is engaging in logical thinking involving the perception, representation , and manipulation of concrete physical objects in the immediate world.

The stage of formal operations, which typically begins around age twelve and continues into adulthood, signifies the child's transition into more abstract and, in that sense, "formal" thinking. The formal thinker moves away from dependence on the physical world for representations of logical operations into a symbolic world of words, numbers, hypotheses, and alternatives. Formal operations involve more systematic thought, an ability to arrive at more general and abstract statements to explain classes of phenomena.

The differences between concrete and formal operations can be exemplified in the task of forming all possible paired combinations of colored beads (Papert, 1980). Concrete-operational children can generate only a random assortment of the combinations. Formal-operational children recognize the rule or "system" for generating all possible alternatives by fixing the color of a first bead and pairing it with all possible colors of a second, then repeating until all possible first colors have been exhausted.

Papert believes that these systematic thinking skills can be discovered and modeled by children working with computers. The above problem of "combinatorial thinking" becomes as easy as instructing the computer to execute a nested loop. Papert's hypothesis is that the computer, by providing a rich environment of models, maps, and systematic procedures, can encourage children to become better thinkers earlier than conventional wisdom about child development would suggest. Other literature from developmental psychology also suggests an earlier development of formal operations when children are confronted with problems that exercise such skills (Kuhn and Angelev, 1975).

An interesting observation on the way in which children approach computers may be cast in such Piagetian stage terms. It has been said that the reason why adults take longer to acclimate to computers is that they, as formal thinkers, need explanations of how the computer works,

not only heuristically but even electronically. Such detailed explanations are difficult to present and unconvincing or confusing to the electronics novice.

On the other hand, concrete-thinking children do not desire such explanations. Using the cognitive tools at their disposal, they employ trial and error, induction, and persistence to arrive at conclusions concerning what things the computer can do and how it can be made to do them. Computers are relatively unambiguous about what is correct versus incorrect procedure. This quality may make them more accessible to the minds of children. That is, children and computers may have concrete thought "in common".

Implied above is the computer's power to mirror children's own thought processes. That is, the computer can lead children to engage in what is known as "reflective thinking," the process of thinking about one's own thinking. For instance, the process of writing and debugging an operating computer program is an exercise in partitioning a problem into smaller and more manageable sub-problems. Often called "procedural thinking," this cognitive skill is one that is constantly aided by the computer as it detects errors and informs the user about them. The concept of a "bug" as a problem and "de-bugging" as problem-solving is a valuable lesson for the child user. Hierarchical thinking may also be encouraged by electronic text systems that present children with decision trees as structures for locating desired information.

Theoretical notions of improved cognitive functioning come to focus in research on children's problem-solving skills, such as that being conducted by Sheingold and Pea (1981) on the impact of computer programming upon formulation of plans, organization of skills, and strategies for solution. Sheingold and Pea believe that computer programming, because it requires procedural thinking and flexibility, can encourage the development of basic problem-solving skills. Their research will investigate not only the types of problem-solving occurring during classroom computer experiences, but also the transfer of such skills to other activities.

Visual Thinking

One interesting hypothesis is whether computers, by displaying graphs, maps, and other visualizations, can encourage that mode of cognition known as "visual thinking" (Arnheim, 1969; McKim, 1980). Salomon (1979) presents evidence that televised presentation of certain visual thinking skills (e.g., rotation of simple objects) can help train children in the internalization of such representations. The stimuli involved are now well within the graphics capability of microcomputers used by children. Visual thinking is often discussed as a basis for creative thinking (Adams, 1974). Many popular video games, such as Adventure, require players to hold in their minds mental representations of complex scenes (e.g., a floorplan, a room filled with objects). Research based on Salomon's concepts and utilizing the visualization capability of computers may lead to a better understanding of the processes involved in visual thinking.

Cognitive Style

Exposure to computers and other electronic text systems may also affect "cognitive style", or those differences in perception, disposition, or temperament that can be distinguished from the exercise of cognitive skills alone (Kagan, 1965, 1966). While further research is needed to distinguish these stylistic aspects of thinking from measures of intelligence and motivation (Gardner, 1978; Haertel, 1978), we can speculate about possible relationships between the use of electronic text systems and cognitive style.

Conceptual tempo -- "reflective" versus "impulsive" thought -- has been studied as one aspect of cognitive style. The reflective thinker takes time in pondering a problem and evaluates many alternatives mentally before responding. The impulsive thinker favors immediate action and selects alternatives with relatively little advance preparation. In general, problem-solving favors the reflective approach.

By stressing trial and error and repeated evaluation of alternatives, computer use may lead to greater planning and reflection by children. On the other hand, reflective children are often blocked by anxiety over being wrong, a trait uncharacteristic of more aggressive, impulsive children. The nature of debugging as learning from one's mistakes may allow children to combine the persistence of reflective thought with a healthier attitude toward failure.

A number of other cognitive style dimensions, including personal construction systems, cognitive complexity, cognitive flexibility, field dependence, processing strategy, and imagery may also affect, and be affected by, electronic text use. The information processing implications of these cognitive style dimensions are discussed by Paisley (1980).

Sex Differences in Cognition

Maccoby and Jacklin (1974) present a thorough review of the the literature on sex differences. Some differences between boys and girls on various cognitive abilities emerge during the grade school years. For instance, after age 10, girls exhibit greater mastery over some verbal skills, while boys begin to excel in spatial and analytic abilities at around age 6 (Haertel, 1978). Such differences may be compounded in the early adolescent years by social and attitudinal factors. For instance, girls often develop negative attitudes toward math and science by age of 12 with the result that, through their avoidance of essential high school courses, their career opportunities are thereafter limited (Fox, 1977).

As discussed above, electronic text systems can offer both boys and girls new experiences and training in cognitive skills. Children's interactions with computers can provide the basis for continued examination of sex differences beginning in childhood and extending into the adult years. It is possible that such differences can be diminished

through boys and girls using computers to master the "weaker" skills of each sex.

ISSUES IN SOCIAL DEVELOPMENT

Our observations, as well as those of other researchers, suggest that computers may have effects not only on children's cognitive development but on their social development as well. Continued exposure to and facility with computers may affect a child's self-confidence, interest patterns, and relations with peers, teachers, and parents -- in short, the child's sense of self. Research points to the crucial nature of successful early experiences, beginning in the preschool years, on the development of a positive self-image (Maccoby, 1980).

Development of Self-Esteem

During their first ten years, children engage in a process of self-definition. They begin to acquire perceptions of their appearance, their skills, and their limitations. They become concerned about how others perceive them -- their friends, their teachers, their parents. They set standards for their own performance in school, hobbies, and friendships. They are building a self-concept.

A common observation among educators is that children exhibit much less computer anxiety than do adults. Much of their natural affinity for computers may be attributed to their perception of the computer as a game. While adults seek to understand the detailed workings of the machine, children are more concerned with what it can do. Positive effects of computer use may be closely tied to children's disposition to use computers playfully.

Children's interactions with computers raise interesting theoretical issues related to the development of self-esteem. "Competence" is one important component of self-esteem (Coopersmith, 1967), and interactions with computers provide one area for the development of competence. The negative attitudes toward computers held by many adults may provide even greater reinforcement of children's self-esteem gained from mastery of the computer. Anecdotes abound of children who have greater facility with microcomputers than their parents. The microcomputer may be, at the present time, the most sophisticated tool that children routinely show adults how to use. Until computer literacy becomes widespread among both children and adults, children who can command computers will find their skills valued and reinforced among peers and adults.

There is another sense in which computers can help build self-esteem. The psychological literature on "locus of control" points to a feeling of control over one's environment as one important component of self-esteem (Brim 1976; Epstein, 1973). In situations where children are programming computers, they are exerting power over a powerful machine. One hypothesis for investigation is whether a child's self-esteem is enhanced by such feelings of control over a computer.

The patience and versatility of microcomputers may especially benefit children whose self-confidence suffers in other learning or performance situations. Children with physical, mental, or emotional disabilities may see themselves as unable to compete with other students at school or with siblings at home. Microcomputers can be "equalizers" for such children, as studies have shown (e.g., Weir, 1981). For example, through the use of templates fitted over the keyboard, cerebral-palsied children are able to write on the computer unhampered by the motor-coordination requirements of handwriting. In the future, we can expect the microcomputer to be an essential tool that allows disabled children to reveal and master skills that have been hidden in the past.

Peer-Group Teaching and Interaction

Observations of children's use of computers in classrooms have often shown a high degree of peer sharing, teaching, and interaction. The exchanges occur in the beginning stages of learning to use the computer and continue through more advanced stages of collaboration in the writing and debugging of complex programs. This interaction among peers is not common in traditional classroom structures. Already, one study (Sheingold and Pea, 1981) is investigating the nature of such interaction and its effects upon learning and affective outcomes.

Interaction focusing on computers may help to break down traditional groupings of children according to sex and age. The presence of computers in classrooms, perhaps the only setting in which pre-adolescent boys and girls work and play together, may help to overcome the stereotype that only boys are skilled in using machines. Also, children from a young age are now instructing adults in the use of microcomputers. The communication facilities of electronic text systems are bringing together groups based on shared interests rather than sex or age.

4. FEATURES ANALYSIS OF ELECTRONIC TEXT SYSTEMS

Like other microprocessor-based technologies, electronic text systems are remarkably varied in their operating characteristics or, within the narrower context of this discussion, the "features" that they present to users at the "interface". The dividing line between structure and function, quite distinct in older print and electronic media, is blurred in electronic text systems by the equivalence of features implemented either in hardware or in software[16]. Because hardware-implemented features are more expensive to change when systems are being modified to perform different functions, there is a design preference for software-implemented features. Software rather than hardware thus determines much of what a user sees and uses in electronic text systems.

As a consequence, the features of electronic text systems have an amorphous reality. To the user who sees and uses them, they are real enough, but instructions in software can change them dramatically. For example, a display of 80 characters per line can be changed, either by pre-programmed instructions or by the user in response to a menu of options, to 40 large characters per line or 20 still-larger characters per line. Electronic text is a very different stimulus when displayed in 80-character lines or 20-character lines, even though the system that displays it is unchanged physically.

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[16] Hardware establishes limits for interface features. For example, a monochromatic monitor cannot display colors. However, most features are implemented well within the hardware limits. The absence of substantively complete or aesthetically pleasing features is often explained by the programming costs of exploiting the full potential of hardware. In other words, it is a software limitation. The distinction is an important one. Generally speaking, only the manufacturer can correct a hardware limitation, but users can acquire more adequate software or even produce it themselves, as thousands of microcomputer users are doing in schools and homes.

Two other examples of software-implemented features help to illustrate the difficulty of a definitive features analysis. First, many microcomputers and some "dumb" terminals have programmable function keys that serve as single-stroke equivalents of typed-in commands. Depending on the application (e.g., editing text, communicating with other users, searching remote databases), programmed function keys stand for "find", "change", "send to", "print", etc. For adult users, function keys are time savers. For children, there probably are compensating advantages and disadvantages. Satisfaction and perseverance in system use may increase as the amount of typing (hence practice in word formation) decreases.

Second, information in digital memory can be presented to the user in various formats. As the information is retrieved from memory, it can be edited in length or terminology. It can be transformed from text to other forms of representation. Instead of being displayed on the screen, it can be directed to a speech synthesizer. Combining the capabilities of several existing systems, it is within the state of the art to display (or speak) the following to the user:

> I have located the information you requested. Would you prefer to review it in the form of...
>
> 1. Spoken synopsis
> 2. Spoken full text
> 3. Displayed synopsis
> 4. Displayed full text
> 5. Statistical tables
> 6. Graphs and pictures[17]

The user can choose one or any combination of these formats. Furthermore, in addition to alternative formats, there are supplementary formats, as when contrasting colors, blinking words, or "voice-overs" provide emphasis, or when background music cues a transition in the text. Given the range of user-selectable formats that are now possible and will soon be common, can we say that children are sharing the same information when they use the same electronic text system to complete the same assignment?

Of course, many electronic text systems have quite limited features. Older systems, some special-purpose systems, and some inexpensive microcomputers provide users with a low-resolution display of uppercase-only

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[17] Resolution in excess of 100,000 pixels (points on the screen) is possible in several electronic text systems. Quite satisfactory pictures can be displayed. However, the digital memory requirements of highly detailed pictures are commensurately high. The burden of picture storage is now shifting from digital memory to videodisc. In the future, videodiscs will be integrated with microcomputers, and random-access pictures may become as common as random-access text is now.

characters. The programmable memories of some systems are too small to store menus of optional features. And the great majority of systems lack the hardware to synthesize speech or to display analog video (videodisc) pictures.

Thus, on the one hand, electronic text systems have two common features of special interest: they all display text, and they are increasingly found in the home and school environments of children.

On the other hand, electronic text systems have a diversity of other features which affect their character as learning tools for children. Moreover, because the other features are often implemented via software rather than hardware, we cannot say, for example, that a system has teletext features, videotext features, interactive cable features, or microcomputer features per se. Feature differences within one of these categories can be as great as feature differences between the categories[18].

We seem to be creating a double bind for ourselves, arguing that the features of electronic text systems should be analyzed but also that the features are too variable to be analyzed. However, the problem becomes manageable if we formulate it differently -- not "What are the possible features of electronic text systems?" but "What are the features of electronic text systems that children most often see and use?"

Features Associated with the Presentation of Information

With the exception of synthesized speech, the presentation features of electronic text systems pertain to the display. Ten years ago, most electronic text was still being displayed at typewriter terminals and teletypes; the display rate averaged 15 characters per second (CPS). Now, most electronic text is displayed at cathode-ray terminals; the display rate averages 120 CPS when remote transmission is involved. When a microcomputer is generating its own display, display rate is determined chiefly by internal processing time, and display rates of 960 CPS are common.

Display rate affects user behavior, learning, and satisfaction. A slow rate of two or three words per second (15 CPS) may be acceptable for young children, but it causes fast readers to "read at the edge" -- that is, to read each word as soon as it appears on the page or screen. Our own experience tells us that this is a fatiguing and inefficient procedure. It requires a greater number of eye movements (saccades) than reading a book page and also deprives the reader of leading context; only trailing context is available to assist in decoding words.

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[18] For example, only a technician could distinguish the high-resolution picture of a TELIDON videotext transmission from a microcomputer's own high-resolution picture, and the low-resolution text of many teletext and videotext systems is indistinguishable from the low-resolution text of many microcomputers.

On the other hand, fast display rates must be interruptable so that text does not scroll off the screen before it can be read[19]. Since a gap exists between the fastest untrained reading rate (about 400 words per minute, or 45 CPS) and the slowest acceptable rate for "paging" new text onto the screen (about 1000 words per minute, or 120 CPS), there should be a convenient interrupt of fast displays.

Character resolution is a second major feature of displays. Even teletype characters of fifty years ago were better formed than the characters now seen by children on many electronic text displays. The concept of "letter-quality" characters, which are an advertised feature of office word processors, becomes an inadvertent pun when we shift the focus of analysis to children's early reading. Most of the characters seen by children on electronic text displays are generated within 5x7 or 7x10 dot matrices. Some distinguishing elements of characters that are important to young readers are traded off in these matrices. The characters that children see on electronic text displays are not the same as the letters they learn to read in books.

Uppercase-only displays are common. For example, the Green Thumb videotext display is uppercase-only, as are the TRS-80 Color Computer, the Texas Instruments 99/4 microcomputer, and the Apple II microcomputer[20]. There is a psychological literature on the "confusion matrices" that result when uppercase and lowercase characters are tachistoscopically displayed. Uppercase characters are involved in many more recognition errors than lowercase characters. However, a child's difficulty with uppercase-only characters extends beyond recognition errors. Principles of capitalization are not reinforced and may be subverted by an uppercase-only display. Distinctions between some proper nouns and some common nouns depend on the capitalization of the proper nouns; in an uppercase-only display the reader must rely on context to distinguish these nouns.

Normal line length ranges from as few as 22 characters (the Commordore VIC-20) to as many as 80 characters (e.g., the Commodore 8032, the TRS-80 Model II) in microcomputer displays. Videotext displays are conventionally 40 characters per line, although the Green Thumb display is 32 characters. Taking 40 characters per line as an average across all

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[19] In an electronic text experiment, Paisley (1979) varied display rate on a cathode-ray terminal from 250 words per minute (about 30 CPS) to 650 words per minute (about 75 CPS) with continuous scrolling. College students had difficulty comprehending technical text at the faster rates, but students with prior computer experience performed significantly better than students without computer experience, controlling for prior knowledge of the subject matter (enzymology, polymer chemistry, and plasma physics). With continuous scrolling, display rates of greater than 400 words per minute seem to impede comprehension among users who were not experienced in reading electronic text.

[20] However, the Apple II can be converted to lowercase at extra cost.

electronic text systems[21], it follows that an average line contains six or seven words. As far as we know, no research has focused on the suitability of such lines for reading at given ages. However, it is interesting to note that lines in children's reading primers also average about six words. In comparison, lines in high school textbooks average about 12 words in a single-column format and 8 words in a double-column format. A popular children's encyclopedia also averages 8 words in a double-column format[22].

Lines per screen range from 16 (TRS-80 Color Computer and Models I and III, HP-85, Green Thumb) to 25 (Commodore PET, IBM Personal Computer). When lines per screen are multiplied by line length, the number of characters per screen ranges from 506 (Commodore VIC-20) and 512 (Green Thumb, TRS-80 Color Computer, HP-85) to 1920 (Apple III and TRS-80 Model II) and 2000 (Commodore 8032, IBM Personal Computer). There is, in other words, a fourfold difference in the screen capacity of these electronic text systems. The smallest-capacity screens can display about 75 words; the largest-capacity screens can display about 300 words. Thinking of the screen as a "window" through which the user sees part of a larger text, small-capacity screens reveal less than a fourth of an average book page, while large-capacity screens reveal almost the entire page.

Graphics resolution has both cognitive and motivational roles to play in electronic text systems. Low-resolution graphics are commonly formed from "building blocks", each composed of scores of pixels and occupying the space of a full character. In the case of a 500-character screen, there are 500 locations where graphic characters of various shapes can be placed. Low-resolution graphics create cartoon-like figures, and diagonals look like stairsteps rather than smooth lines.

High-resolution graphics are formed by "turning on" individual pixels in white, black (reverse video), or chosen colors. Children seldom have an opportunity to see the highest-resolution graphics, which are produced by special graphics terminals. However, the high-resolution graphics of TELIDON-type videotext systems and many microcomputers rival the picture quality of color television[23]. The programming effort required

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[21] This happens to be the line length of the Apple II, Atari 400 and 800, and Commodore PET, which, together with the 64-character TRS-80 Models I and III, are most widely used in schools.

[22] These averages are based on a small sample of books and should not be taken as definitive.

[23] In fact, what the user sees in most cases is color television. The digital signals are modulated onto a television-frequency carrier and received by television sets on open channels. Somewhat higher resolution is obtained by sending the digital signal directly to a monitor without modulation. Among popular microcomputers, modulation is the default approach for Atari, TRS-80 Color Computer, Commodore VIC-20, Sinclair, etc., while direct connection to a monitor is the

to create a high-resolution display is often massive; the best examples are now recognized as a form of computer art.

Motion is another feature of graphic displays. Convincing simulations of real-world processes (e.g., growth, flow, collision and rebound) require rapid motion. Some microcomputers, notably the Atari, have the ability to depict rapid motion[24]. Like high-resolution graphics, motion graphics depend on complex programs, usually written in "machine language" rather than a higher-level language like BASIC or PASCAL in order to speed up execution.

Color is a feature of almost all teletext and videotext systems. Microcomputers are divided between a majority that provide color (led, we might say, by Apple and Atari) and a minority that do not (led by the TRS-80 Models I and III and the Commodore Pet). Over decades of research concerning the benefits of color versus black-and-white in instructional film, television, etc., the consensus of findings is that color has little effect on cognitive learning, either positively or negatively, but that color may be an important motivator in situations where the user sets his or her own level of concentration and perseverance. As the foreground or background of a text display, the pleasing effects of color must be balanced against the somewhat lower resolution ("fuzzy edges") caused by the color burst signal.

Music and sound effects are commonly available on microcomputers used by children. Even the business-oriented IBM Personal Computer provides this feature. Special programming efforts are required to generate music at true pitch, because the digital pulses that form musical tones are mathematically derived from the microcomputer's internal "clock" and are only approximations of the frequencies of the tempered scale. However, microcomputer music, which sounds like a reed instrument because of its square waveshape, can be an attractive accompaniment to displays.

Synthesized speech is a standard feature of one microcomputer, the TI 99/4, and is also available for Apple, TRS-80, Commodore, and other microcomputers. In the past year or two the vocabulary and vocal quality of synthesized speech have improved markedly. One device, the Votrax Type'n'Talk, follows complex phonetic instructions as it pronounces words, phrases, or even entire texts. The Type'n'Talk, more than any other microcomputer device now available, can show children the interrelationship of written and spoken language.

Keyboard symbols, labels, and layout are not usually regarded as presentation features, but in fact children may learn much about language and the control of computer/communication devices from them. Optimal keyboard arrangement of letters for children's use is an

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default approach for Apple, TI 99/4, IBM Personal Computer, etc.

[24] Atari calls this feature "player-missile graphics", which illustrates how a powerful general feature may originate in a special application.

unresolved issue. Advocates of an "ABCDEF" arrangement believe that children's keyboard use should reinforce language learning, while advocates of the conventional "QWERTY" arrangement argue that children's keyboard use should create transferrable skills so that they can readily use conventional typewriters and other "QWERTY" keyboard devices.

Other features of the keyboard, such as punctuation, mathematical symbols, function keys, etc., probably help children to understand the range of symbols used in human communication. The keyboard shows all symbols simultaneously and in an orderly pattern that children can study, whereas the display shows only a subset of symbols in a changing pattern.

Features Associated with Inputting and Commanding

Keyboards, keypads, and other input devices are indeed the "key" not only to the user's actual control of an electronic text system but also his or her sense of control over the system. All microcomputers in general use are controlled by full alphanumeric keyboards averaging 70 or so keys, while most teletext, videotext, and interactive cable systems are controlled by numeric keypads averaging 16 keys.

Full keyboards allow the user to interact with the electronic text system in two ways: (1) responding to "menu" choices, and (2) initiating interaction through a command language (see below). Keypads generally allow response to menu choices only. In most teletext, videotext, and interactive cable applications, a full keyboard has too much interaction capacity for the system. In most microcomputer applications, a keypad has too little interaction capacity.

The optimal design of keyboards and keypads will be a challenging topic for the next decade or more. However, the highest priority for keyboard and keypad design at the present time is to remove unnecessary complexity[25] and to ensure "crashproof" interaction. It is a frequent and frustrating experience for microcomputer users of all ages to "crash" programs by inadvertently pressing the break, reset, or other control keys. Trained users know how to restart an interrupted program; others must wait helplessly for someone's help in restarting the program. In the worst case, a "crash" erases the program from memory and it must be reloaded.

Teachers belonging to associations like Computer Using Educators share strategies for making keyboards "crashproof". They place rubber washers under keycaps; they block access to reset buttons, etc. They believe that, while the first requisite for children's learning from microcomputers is to provide good programs, the second requisite is to keep the programs running.

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[25] Microcomputer keyboards have several keys that are primarily for programmers' use. These cryptically labeled keys may distract users of application programs.

The ratio of correct to incorrect responses, hence positive to negative reinforcement, can be increased by focusing children's attention only on the keys that are required by a given program. Simplified auxiliary keyboards or keypads can be cabled into the microcomputer, and its own keyboard can be removed from use (e.g., hidden under the monitor's pedestal). An auxiliary keyboard for a spelling program, for example, can be limited to the 26 letters plus embedded punctuation such as the hyphen and apostrophe. An auxiliary keypad for an arithmetic program can be limited to the 10 numbers plus decimal point and mathematical operators.

Analog input devices like the joysticks and paddles used in games can provide responses to instructional programs as well. Children like the vigorous action of these devices. We might hypothesize that children prefer moving a pointer to the correct response with a joystick rather than typing the response.

Teletext/videotext keypads appear to be easily used by children. In most cases the keypads resemble telephone keypads that children already know how to use. The 16-key pad of the Green Thumb Box created no problems for children in our study, nor did the 16-key pad of the Channel 2000 system[26].

Voice input has been discussed as an optimal solution for inexperienced users, but speech recognition software has a long way to go before children's speech can reliably command electronic text systems. During the next decade or so, children using speech recognition devices, which are available for several microcomputers, may be frustrated in making themselves understood by the computer, but they will learn valuable lessons about pronunciation and articulation.

Menus and other structured choices are often a user's first exposure to the way electronic text systems "think". Most menus are implicit or explicit decision trees. Initial choices are made among substantive alternatives such as one set of problems versus another (e.g., addition versus multiplication, word definition versus spelling). Later choices are made among procedural alternatives such as difficulty level.

In the case of videotext systems, initial choices are made among text files to be displayed. Intermediate choices are those of searching by title or keyword, paging forward and backward, holding text on the screen, etc. Later choices allow additional functions to be performed. Depending on the videotext system, later choices include text editing, performing calculations, ordering items or services, sending messages to other users, etc.

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[26] The Channel 2000 or Viewtel keypad has keys labeled GET, JUMP, FWD, BACK, DO IT, and OOPS. One push of the OOPS key cancels a mistake; two pushes request help from the system.

Users become impatient with menus after a number of practice sessions, especially if the menus are self-evident or verbose. When given the choice, users often prefer a command language that allows them to proceed directly to an activity that may be located several branches down a decision tree.

Command languages are sometimes programming languages. That is, a user can command microcomputer functions directly in BASIC. In effect, a BASIC program can be typed and executed one statement at a time (e.g., to check the logic or executability of each statement).

More often, command languages are embedded in programs whose statements the user doesn't see. The host program may be written in machine language, which is cryptic to most users. However, a well-written command language makes the user feel that he or she has a large measure of control over the system; the handiwork of the original programmer is invisible for the most part. Most important, command languages allow the user to initiate interaction and not merely to respond to the system's menus.

LOGO is a powerful example of a programming language that is intended to be used as a command language as well. Unlike most programming languages, it requires no "housekeeping" statements to clear memory, define variables, dimension arrays, etc. In the illustrations made famous by the book Mindstorms (Papert, 1980), a child can command the computer to draw a square and triangle as follows:

```
TO SQUARE
REPEAT 4
  FORWARD 100
  RIGHT 90
END
```

```
TO TRIANGLE
REPEAT 3
  FORWARD 100
  LEFT 120
END
```

SQUARE and TRIANGLE can then be used as subprograms in HOUSE:

```
TO HOUSE
SQUARE
TRIANGLE
END
```

When the child commands HOUSE, the triangle will be drawn on the square. As a command language, LOGO allows the user to see immediately whether a statement produces the desired effect. However, the computer also stores statements to be used as subprograms in more complex programs.

Features Associated with Content

Important as the foregoing features are in creating contexts for interaction, the major effects of electronic text systems on children's learning are probably determined by the systems' content features -- their substantive programs, files, and databases. The features of four categories of content are discussed below.

Instructional software has become a major research, development, and distribution industry. It is beyond the scope of this report to characterize all the varieties of instructional software that children use. However, the evolution of instructional software from its beginnings in the 1950s to the present time suggests a succession of major types that were developed as computer capabilities grew.

Drill and practice software emerged first because it was relatively easy to program and required the least memory[27]. Problem sets and questions with fixed responses are the core of drill and practice software. Although some drill and practice programs are criticized for their repetitiousness and lack of reinforcement, the continuing strengths of this approach are its comprehensibility to students, its "patience", its immediate feedback, and its ability to adjust the level of problem difficulty according to each student's performance. Its major weakness is its inability to teach the facts, rules, or skills it is testing. Backward branches from incorrect responses to simpler problems will help students only if they understand in principle what the problems are testing.

Tutorial software complements drill and practice software, and the two can be combined in productive sequences. Tutoring requires much more memory than drilling. "Memory-bound" systems such as small microcomputers[28] cannot run long tutorial programs.

With the advent of high-resolution graphics, it has become possible to add detailed graphs, diagrams, and pictures to tutorial software. This is a major change from text-only software, but the learning benefits of the new mixed-format displays have not yet been studied to any extent.

Simulations, the third common form of instructional software, require large memory capacity and high-resolution graphics. Simulations of physical or social processes can be presented within tutorial sequences. For example, a lesson on genetics can include a simulation of the descent of traits through many generations of drosophila. More so than in the case of drill and practice or tutorial software, simulation

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[27] At the programming level, a drill and practice sequence often consists of a small number of question frames containing blanks. Words or phrases stored efficiently in another array are entered into the blanks when the questions appear on the screen. In the case of arithmetic problems, memory requirements are minimal, since numbers used in the problems can be generated randomly for a given difficulty level.

[28] Despite the apparent specificity of the "micro" name, there are great differences in the memory capacity of microcomputers. Many machines are still being sold with only 4,000 (or 4K) characters of memory capacity. The industry standard is moving toward 64K characters; because of new memory "chips" that are entering production, it will soon be 128K on its way to 256K.

utilizes the unique capabilities of the computer to depict rule-governed changes in physical or social systems.

A final step beyond drill and practice, tutorial, and simulation (for now) is discovery software, which hides its lessons in a powerful capability for the student to explore numeric, graphic, or textual relationships. Naturally, since the computer is not directing interaction toward "its own" objectives, discovery software utilizes command languages rather than menus. Furthermore, the command languages are designed with a simple terminology and syntax so that even a novice user can advance quickly from procedural learning to discovery learning.

The memory requirements of discovery software are determined by the extent of the numeric, graphic, or textual domain that the computer covertly[29] holds open for the user to explore. For example, the popular LOGO software requires 48K memory to allow exploration of an extensive graphic domain[30]. Numeric domains require less memory because their structure can be extended on the basis of computations only. Textual domains require much more memory because their contents must be stored as words (or "string literals" in programming parlance). The Adventure game known to many children and some adults is discovery software based on a textual domain. Adventure "journeys" appear to be topographical but are actually implemented by text processing.

The more powerful discovery software is, the more it relies on computer understanding of the user's natural language commands. Whereas the limits of drill and practice, tutorial, and simulation software are inherent in their structured interaction, the limits of discovery software will be extended by each advance in artificial intelligence research.

Text files are the second category of content whose features warrant discussion. Teletext and videotext systems offer a variety of text files ranging from the day's news to encyclopedias and literature. Unlike instructional software, these files are structured for reading straight through. The user's command prerogatives are limited to selecting files and paging through them. However, users of all ages find some magic[31] in their ability to call up entire newspapers and books for reading on the screen.

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[29] Any adverb used in this context is somewhat misleading. The computer "knows" its limits in allowing the user to explore a domain, but the user should be more aware of what the software can do than what it cannot do.

[30] Compare this memory requirement with the range of microcomputer memories cited in footnote 28.

[31] It has been said (we regret we cannot remember by whom) that any sufficiently advanced technology is indistinguishable from magic.

Our site visits and other observations suggest that children are willing to "try harder"[32] to read electronic text than printed text. Children's indifference to print media such as newspapers (except the comics) is well established in communication research, yet we observed, particularly in Green Thumb homes, that children will call up and read newspaper-like files from a videotext system.

If the example set by early electronic text systems helps to determine the content of later systems, then text files prepared for children will be a common feature. Through the 4-H division of the Cooperative Extension Service, the Green Thumb system provided local 4-H news and career exploration information. The latter file, entitled "The World of Work" on the videotext menu, eventually contained 60 frames; part of it could be played as a game.

As described in Section 2, Channel 2000's videotext service in Columbus provided different text files for younger and older children. Early Reader involved parents in teaching word relationships to preschool children. Math That Counts offered problem sets grouped by grade level for kindergarten through sixth-grade children[33]. Older children made frequent use of the Academic American Encyclopedia. Use of this resource was facilitated by Channel 2000's help command (a double OOPS -- see footnote 26) and BOOKMARK, a feature that remembered the user's place at the end of a session and started the next session with the same frame.

Teletext systems differ from videotext systems in the limited number of frames that can be broadcast at one time. Special activities and information for children are usually scheduled for hours when children are likely to use them. For example, the WETA teletext system in Washington broadcasts children's frames on Saturday morning. Typically, it would take half an hour for a child to read all the frames and participate in all the activities. An equivalent feature of the KCET teletext system in Los Angeles is entitled Popsicle.

Of course, children's use of videotext and teletext systems is not limited to files created especially for them. Children in Green Thumb homes often accessed weather and farming information; in some homes it was their role to read such information and tell their parents the gist of it (e.g., "Looks bad for haying until Thursday"). Other systems

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[32] Our colleague Eduardo Navas commented here that many children in non-English-speaking countries learn to read better when American films, which the children flock to see, are subtitled in the language of the country rather than dubbed. There is strong motivation to read what Luke Skywalker said to Darth Vader.

[33] We will beg the question of whether these text files should be classified as instructional software. The user of a videotext system must navigate through verbal decision trees even to reach a set of mathematics problems. Except for very young children, parents or other adults do not set up the problems on every occasion.

offer community information of interest to both adults and children. Channel 2000 divided community information into two files, the Public Information Service and the Community Calendar.

Because text files are so diverse, it is difficult to specify their features with respect to children's use. Some differences between instructional software and text files are apparent, however. Most instructional software is highly interactive. It is also directive; the student cannot "break out" and browse through any files that he or she wishes to. In comparison, text files offer the limited interaction of selecting files and paging through them. Text files are nondirective; they can be used for any length of time in any sequence.

Message files, the third category of content, are very popular with children who have access to them. Three types of message files are available on various videotext systems:

1. Electronic mail, "posted" from one computer or terminal to another for delayed receipt. Also known as asynchronous messaging, electronic mail deposits a message in the "electronic mailbox" of one or more other users, who can call it up for reading whenever they wish.

2. Electronic conversation, a synchronous or same-time exchange between two or more system users, displays messages immediately. Normally, conversations do not leave a record in the computer's memory, as electronic mail does.

3. Electronic bulletin board, a facility for making announcements to all users of the system. Because of the number of announcements "on the board" at the same time, they are stored within subject areas and/or are searchable by keywords.

The SOURCE videotext system, among others, offers all three of these services. MAIL can be sent to as many as 200 other users at a time, addressed to their individual account numbers. Received messages can be stored for future reference; they can be edited for inclusion in a text file the user is creating; they can also be forwarded, with comments, to other users. CHAT is invoked simply by entering another user's account number followed by a message. POST allows announcement to be placed in any of 79 categories (currently). The announcements stay on the bulletin board for two weeks.

Several explanations have been advanced for the appeal of these services to older children. First, there is the opportunity to have electronic pen-pals who share interests in hobbies or activities. Months-long electronic exchanges have been conducted by adolescents who never met face to face. Second, we noted that electronic "interest groups" span a wider age range than face-to-face groups. Because face-to-face cues and norms are lacking, each message sender tends to be judged by the merits of the message itself. A literate adolescent may find more

adult acceptance in an electronic interest group than in face-to-face encounters with adults. Third, the simplicity of composing and editing electronic messages contrasts with a young writer's difficulty in composing handwritten or typewritten messages[34]. On the average, electronic messages are also briefer than their counterparts in written or oral communication. A young writer's tendency to use up his or her ideas in a few sentences does not result in an abnormally short electronic message.

Of all the written communication that reaches us, as children or adults, personal messages probably receive the most careful and thorough reading. However, children receive few personal messages in the course of school or home activities. In contrast, electronic mail and conversation generate a vigorous flow of messages. We have observed that children's willingness to compose electronic messages is more than matched by their willingness to read messages sent by others. Thus children who have access to these facilities benefit doubly from the writing and reading practice.

Other databases, our last content category, is even more heterogeneous than the previous categories. One of Channel 2000's services, the "Video Catalog", would be classified as a database because of the format in which it held 300,000 records of the Columbus and Franklin County Public Library[35]. Other examples of databases include stock market quotations; product, service and entertainment listings; sports scores; and of course numerical data from the Census and other sources.

Children access some of these databases (e.g., sports scores) out of curiosity. Other databases can be used to complete school assignments. For example, students beyond the sixth grade often "play the stock market" as a social studies or economics assignment. They "invest" a hypothetical "stake" and monitor their investments for several weeks. Teachers and parents can attest to the seriousness with which young financiers compare the performance of "their" stocks with those chosen by classmates.

In terms of skill acquisition, however, the most important databases that many students search are indexes to newspapers, magazines, and scholarly literature. Resources that were once available only in large libraries are now offered to home subscribers by videotext services like CompuServe and The Source. Children are already using these online resources for schoolwork. Skills once acquired in college, if ever, are being practiced by children in middle and high school.

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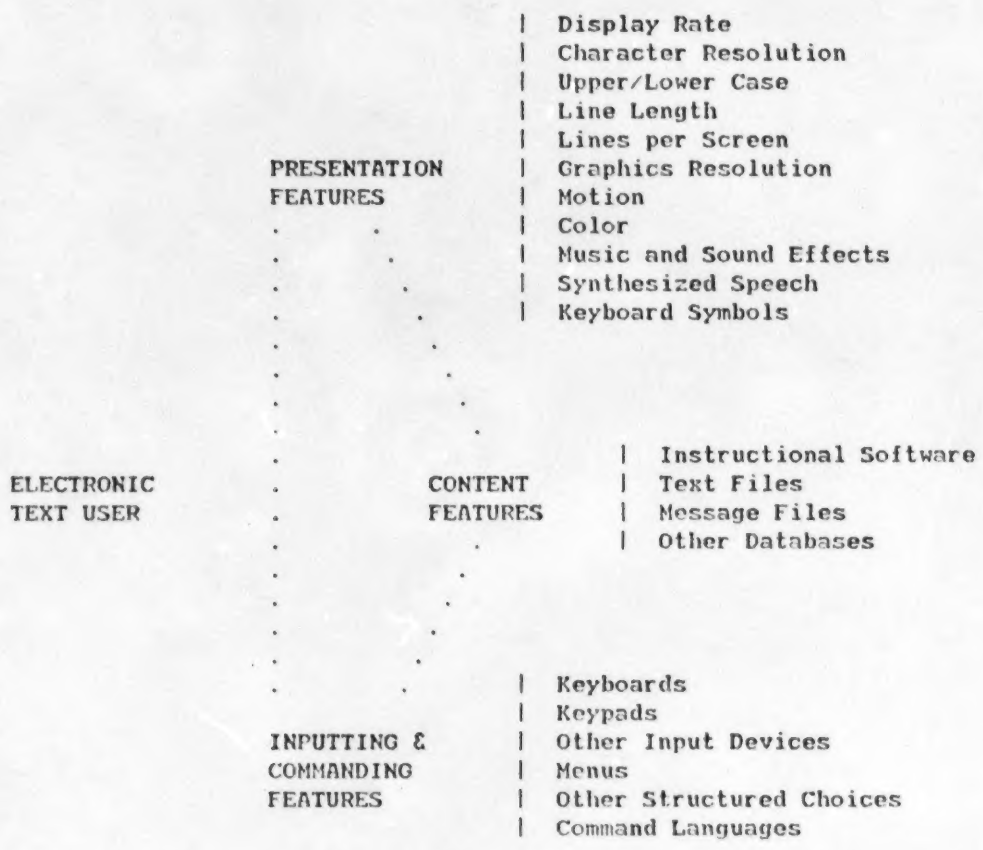
[34] The 9th-grade son of one of us composes and edits his book reports on an Osborne microcomputer, using Wordstar. In appearance and substance they are much better than his previous handwritten efforts.

[35] Even a text file would be classified as a database if its records are organized for multi-access searching rather than continuous reading. Journal abstracts, movie reviews, recipes, etc., have a dual status as text files and databases.

Summary of Features

The following figure summarizes the three categories of electronic text system features that have been discussed in this section:



5. IMPLICATIONS FOR FURTHER RESEARCH

ANALOGY WITH TELEVISION RESEARCH

Systematic studies of the effects of electronic text systems on children's learning are just beginning at a number of research centers in the United States and other countries. We know as little about these effects today as we knew about the effects of television in 1955, before the landmark studies such as Television and the Child (Himmelweit, Oppenheim, and Vince, 1958) and Television in the Lives of Our Children (Schramm, Lyle, and Parker, 1961) were conducted. In the past quarter-century, research on children and television has occupied scores of researchers. Thanks to the development of close relationships between researchers and producers, the growing knowledge of television's effects on children has led to more effective programming[36].

The issues that merit research on children and electronic text systems, and the potential benefits of such research, parallel those of television. However, it is unlikely that research on electronic text systems will parallel television research in two important aspects. First, it is often suggested that electronic text systems will have transformative rather than supplemental effects on children's learning. Thus researchers studying electronic text systems as learning media for children should be prepared to derive new paradigms of effect from the findings of studies yet to be conducted. Second, whereas television technology changed little in a quarter-century, the technologies of electronic text systems are changing at a rate that amazes "technology watchers" and perplexes decision makers.

BASIC AND APPLIED RESEARCH

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[36] Television studies, as much as any field of social research, led to the development of formative evaluation methods that assist, rather than simply "pass judgment on", program development. The close coordination of research and production is epitomized by the well-known programs of the Children's Television Workshop (see Palmer, 1974)

Basic research on children and electronic text systems should be committed to long-term programs organized, initially, around the psychological and sociological effect paradigms of previous research on learning media. Lest we imply that research on electronic text systems will shift entirely to new paradigms, we will predict that many basic problems investigated by researchers in the past[37] will continue to be investigated in a similar manner in the future. Other continuities of research will be discovered when new topics receive their first careful examination. For example, the principles of learning from discovery software may be found to be rooted in Gestalt psychology.

At the same time, applied research on electronic text systems should be adapted to the changing technologies and the new uses and users of the systems. Issues of usability and equity in the next decade should not be ignored or deferred because of the prospect that electronic text systems will be extremely easy to use or ubiquitously available by the century's end.

Lasswellian Paradigm

Research on electronic text systems may follow a variation of Lasswell's paradigm for communication research (1948): Who says what to whom through which channel and with what effects? The variation, which will necessarily be receiver-oriented rather than sender-oriented, may be: Who learns what from which electronic text system and with what effects on other learning and behavior?

THREE LEVELS OF INQUIRY

This paradigm raises research questions at three levels of inquiry -- demographic, sociological, and psychological. We will discuss several such questions below

Who...

Which groups in the society have access to electronic text systems? Present access to electronic text systems is strongly influenced by socioeconomic status and place of residence. Socioeconomic status affects not only the purchase of electronic text equipment (e.g., microcomputer, teletext and videotext terminal/decoder) but also the perception of utility in electronic text systems. For example, up-to-the-minute financial reports are valued more by investors than by non-investors.

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[37] One of the most significant of these, in our opinion, is aptitude-treatment interaction, ably studied by Cronbach and Snow (1977). Their research design can encompass interactions between the features of electronic text systems and individual differences among learners.

Place of residence affects teletext, videotext, and interactive cable service. These services will spread in metropolitan areas during this decade, but small towns and rural areas not served by metropolitan broadcasting will be slow to receive teletext service. Small towns will have access to interactive cable and videotext service, albeit more slowly than metropolitan areas. Rural areas will be poorly served until rooftop reception from satellites becomes cheaper. Cable operators avoid the front-end costs of running lines to widely separated rural homes. Videotext service is not available to the many rural families who have "party-line" telephones.

What are the barriers to access and how can they be overcome? Cost may soon be the least significant barrier to access. Market forces have already reduced the cost of microcomputers to a level that households have long been paying for color television sets and related equipment. The $100 microcomputer, on sale in 1982, may fill niches in household use much as radios now do -- that is, more than one such microcomputer will be located around the house where adults or children wish to use them. Teletext and videotext terminals and decoders will become trivially cheap (by the standards of other household expenses) in mass production. Interactive cable service may always be somewhat more expensive than the other electronic text technologies because of the rising costs of the dedicated lines and the personnel that interactive cable requires (based on the QUBE model).

Where place of residence limits access to electronic text, as in many rural areas, several solutions may be explored. The first solution, which rural dwellers have traditionally chosen, is self-sufficiency. Microcomputers and their extensive software libraries do not depend on telephone or cable lines or on broadcast signals from metropolitan areas. Videodiscs are a complementary storage medium for random access to high-resolution graphic or pictorial images.

A second solution is more rapid development of low-cost satellite transmission to homes[38]. Direct satellite transmission is becoming, by necessity, a major communication link in the Third World. Equipment tested in these applications is now reaching the domestic market, but it is still too expensive for widespread adoption. A small number of satellite channels can meet the needs of a rural area for television signals and digital transmissions to electronic text equipment.

A third solution is government or other subsidy of rural cabling, similar in principle to the rural electrification program. A loan program which provides the front-end funds for cabling and is repaid by a small surcharge on cable subscriptions over the life of the system would

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[38] The cost referred to is that of receiving equipment -- the "dish" and high-frequency receiver. This is the cost that households must bear directly. The cost of satellites capable of transmitting clear signals to small rooftop receivers will probably be higher than the cost of satellites that transmit to large "dishes", but the fraction of the cost that would be passed on to each user would be minimal.

serve the same purpose.

Which groups make greater or lesser use of public access systems (i.e., those in public facilities such as libraries and museums)? This question cannot be discussed without a hard look at the concept of "equal access". If public libraries begin to offer access to electronic text equipment (as they will) to all persons in a community, is that equal access? In the "formalist" sense of equity (Harvey, 1980), the answer is yes. In the "actualist" sense, the answer is no. Formal equity is concerned with barriers to access that lie outside a person -- laws, sanctions, customs, etc. If there are no such barriers to access, then formal equity is said to be present. However, barriers to access also lie inside people -- in a lack of education, lack of experience, inability to formulate strategies, lack of self-confidence and sense of personal efficacy, etc. These internal barriers largely account for the gap between formal equity and actual equity.

Other media, rich with relevant information and simple to use, are widely available in communities, but they are not used equally by everyone. Contrary to equity goals, these media are used more by the groups that already have the most information -- the "information haves".

We believe that electronic text systems do differ from traditional information media in the crucial balance of informativeness relative to accessibility. "Information have nots" may use electronic text systems more than traditional information media. Whether electronic text systems can overcome major internal barriers is a question for research, however.

Within social groups, what are the group roles of those who make greater or lesser use of electronic text systems? Social groups can be analyzed in terms of many permanent and temporary roles that members play. In addition to the roles of leader and facilitator (and, of course, follower and obstructor), the role of innovator is significant in groups that are undergoing change. If the decision to adopt new practices is "top down" rather than "bottom up", then the leader's role may be more important than the innovator's. If the decision is "bottom up", then the innovator comes into his or her own.

In groups of children, up to the present time, those who have interest and ability in working with computers have often been characterized as "outsiders" and "loners". The machines that they used were mysterious; so, by association, were they. They had little influence with their peers, and in any event there were few practical ways in which they could induce their peers to use computers, since the computers were not available.

We believe that both the facts and the stereotypes concerning "computer kids" are changing. Computers have moved from the back rooms to executives' desks, from the science lab to the poetry class, and from specialized magazines to the covers of Time and Newsweek. Is it now "cool" to be a computer kid? Are such children well integrated in their peer groups and classrooms? These questions could be answered through

further study of group roles in settings where microcomputers are extensively used.

What are the individual characteristics of those who make greater of lesser use of electronic text systems? Demographic analyses of the young audience for television have continued from the 1950s to the present day. Such analyses confirm some hypotheses about children as television viewers and disconfirm others. Non-obvious findings, such as the decline in television viewing during the late teens, are more credible when documented in large-scale surveys than in anecdotal data. Demographic analyses, by sex, age, race, school achievement, and other variables, should now be conducted of children using electronic text systems. In other words (simplifying the title a bit), the field needs a study entitled Computers in the Lives of Our Children to complement the pioneering study of television by Schramm, Lyle and Parker (1961).

Learns What...

Which content resources are used? By which groups of users? This is a further aspect of "audience analysis" by analogy with television research. Steiner (1963) noted the differing "diets" that television audience subgroups chose from the "menu" of television fare. Newspaper and magazine readership studies are a similar genre of research. In the case of electronic text systems, we want to know what instructional software, text files, message files, and other databases users are selecting.

It may be difficult to determine which content resources are used in the case of proprietary electronic text systems, since they lack the economic incentive of older media to reveal the popularity of their offerings[39]. However, an independent survey could begin with randomly sampled homes and schools in order to determine, from the statements of users themselves, which content resources are being used, and by whom.

What levels of learning are attained? Levels of learning can be categorized as association, discrimination, rule learning, and principle learning (Gagne, 1970) or as knowledge of specifics, comprehension, application, analysis, synthesis, and evaluation (Bloom et al., 1956). What levels of learning are attained by users of the four major types of instructional software? When instructional software can be "played" casually, how do learning benefits compare with its use in directed (i.e., study) mode? What are the learning benefits of casual use of text files, message files, and other databases? Of directed use of these other forms of content?

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[39] Audience and readership studies are primarily conducted to prove to advertisers that television, newspapers, and magazines have wide appeal or high coverage in sought-after markets. Proprietary electronic text systems carry no advertising (yet) and thus have no incentive to disclose their market data.

What are the secondary and/or unintended learning outcomes? Each learning medium and setting, including school itself, teaches students many lessons beyond those provided for in the curriculum. To paraphrase McLuhan (1964), the medium is a message in each case. Sometimes it is surprising to find out what the message is. Electronic text systems have a variety of implicit messages -- in this case, facts about the world that children learn while using the systems for other purposes. At the very least, they note the ways in which knowledge is organized and information conveyed. They may note the internationalism and pluralism of knowledge. They may note recurring themes in American society. They may learn lessons about themselves; they may be surprised that they can understand information intended for adults[40].

Secondary learning of skills is almost certain. Electronic text systems provide opportunities to practice reading, to translate written instructions and choices into action, to compose statements and commands, to coordinate eyes and hands, etc.

From Which Electronic Text System...

Is there differential use of particular electronic text systems by group or individual characteristics? There is much functional overlap among electronic text systems, but, to choose extreme examples, children who used only teletext systems and other children who used only microcomputers would probably develop different knowledge, skills, and attitudes. The "teletext children" would be observers of a world crowded with bulletins, reports, and updates on events of all kinds -- a world where facts beggar the imagination. The "microcomputer children" would be actors in a smaller world where they control events, where relationships between causes and events are clearly seen, where problems are solvable. Although neither of these extreme cases is likely to occur, it will be important to know the extent to which differential use of the systems is occurring and which groups or individuals account for the differential use.

Over time, do particular electronic text systems have an increasing potential for learning, while other systems reach limits inherent in their technologies or use environments? In other words, do the four types of systems have equally bright futures as learning media? Or will the simplest system, teletext, soon be passed over for the power for videotext or interactive cable[41]? In the not-distant future, will schools and homes both opt for the combination of microcomputers and interactive cable systems over which entire libraries of programs can be "downloaded"? Should researchers try to foresee the outcomes of technological progress and market competition in order to study the effects,

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[40] Children's school experience largely insulates them from adult material. Textbooks and even classroom newspapers are written down to them.

[41] Microcomputers are not functional rivals of teletext systems.

and the more effective use, of the eventual "winners" rather than the eventual "losers"?

With What Effects on Other Learning...

Does learning from electronic text systems reinforce, or conflict with, other forms of learning? Ten years ago the advocates of individualized instruction had to admit that children could not be started in individualized programs in grade school, then funneled into conventional whole-class programs in middle or high school. The one experience "maladjusted" them for the other, not only in level of preparation (in that some children had progressed individually far beyond the whole-class curriculum, while other children were not ready for it) but also in attitude. Will electronic text systems "maladjust" children for other classroom learning, including instruction from the teacher? Will they be less able to learn without buttons for "back up" and "go forward faster"? Or, on the contrary, will learning from electronic text systems be a catalyst for classroom instruction and discussion?

Do children who use electronic text systems extensively have a richer or poorer home and school experience otherwise? With electronic text systems in both environments, will school days and home evenings flow together in a continuous learning experience? Will children come to school with their unfulfilled curiosity and enthusiasm from electronic text activity at home, and will they take home the stimulation of electronic text activity at school? Or will there be "electronic text burnout" -- too much information, too many questions, too many possibilities, all of it too fast[42]?

With What Effects on Behavior...

What are the effects of electronic text use on children's personal adjustments? On their social development? On their interaction with other children and with adults? These questions all ask, in different ways, whether electronic text systems will help children grow personally and socially. On the one hand, the answer deserves to be, "It depends", which is as close to a final verdict as 25 years of research on children and television has reached. On the other hand, electronic text systems are different from television, and another answer, "It depends, but quite differently", is pregnant with possibilities for research.

On one point, we believe that fears concerning electronic text systems are wrong. The use of electronic text systems does not separate people; it brings them together. A roomful of microcomputers produces not only conversation but conviviality among children. The most popular

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[42] The book, The Soul of a New Machine (Kidder, 1981), tells of an engineer who gave up trying to design a super-fast computer, decamped, and left behind a note, "I'm going to a commune in Vermont and will deal with no unit of time shorter than a season."

features of videotext systems include their "CB" conversations, their electronic mail, and their bulletin boards. In homes where electronic text systems are used by both children and adults, "what's on the system" is a livelier topic of conversation than "what's on TV". The general finding may be that instructive, funny, difficult, disastrous and/or rewarding experiences with intelligent machines are excellent topics of conversation. This is not a trivial finding when, as we have observed, the conversations cross age lines and the content of the conversations ranges across all the things that intelligent machines can do.

The larger questions of the effects of electronic text systems on children's personal and social growth must be left for research. The potential for some adverse effects is inherent in the often-compelling nature of the interaction that the systems provide. A few children may "overdose" on the stimulation that simply motivates learning among other children. Malone's analysis of "what makes things fun to learn" (1980) identifies the elements of challenge, fantasy, curiosity, variable difficulty level, multiple level goals, hidden information, and randomness in learning as well as play. The potential for harm may covary with the potential for good in all technologies, just as it does in all human arrangements.

Temporal Frames of Reference

More than one temporal frame of reference is implicit in these questions. Electronic text systems are a new phenomenon. Outside of computer-related professions, few adults and even fewer children had contact with electronic text prior to this decade. Most children that we observed were still learning how to use the systems. We observed a high proportion of procedure learning relative to content learning.

Social researchers sometimes use the "loaf of bread" analogy to describe differences between periods when new behaviors are initiated and later periods when the behaviors have reached equilibrium with respect to other behaviors. The majority of slices in a loaf of bread are uniform, and one or more of them can be sampled to represent the others. However, the end of the loaf has some slices that differ from the majority and from each other in size and texture. Similarly, the early adoption period of a social or technological innovation almost certainly differs in "size and texture" from later periods.

To complicate matters further, "early" and "late" can refer both to the life cycle of a technological innovation itself and to an individual's contact with it. By the turn of the century, which we assume will be fairly late in the life cycle of electronic text systems as we now know them, there will still be individuals who have no contact with the systems. Others at that time will just be initiating contact. Even apart from technological progress per se, initial contact with electronic text systems in 2000 will be qualitatively different than in 1982.

Thus research on children's use of electronic text systems should focus on both the period of initial contact, when use procedures are being learned and attitudes toward the systems are being formed, and the later period of proficient regular use integrated with other activities. These periods of individual contact with electronic text systems should be studied continuously throughout a substantial part of the life cycle of the systems as well.

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